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INNOVATIVE TECHNOLOGY
Summary Report

LANL Electrolytic Decontamination Technology for use in D&D Environments

Deactivation and Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

LANL Electrolytic Decontamination Technology for use in D&D Environments

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Deactivation and Decommissioning Focus Area

Demonstrated at
Los Alamos National Laboratory
Los Alamos, New Mexico

Purpose of this document

Innovative Technology Summary Reports (ITSR) are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem.

The purpose of an ITSR is to describe a technology, system, or process that has been developed and tested with funding from the U.S. Department of Energy's (DOE) Office of Science and Technology (OST). Each report presents the full range of application for the technology, system, or process and the advantages to DOE in terms of technology performance, cost, and effectiveness. Most reports include comparisons to baseline and/or competing technologies. Information about commercial availability and technology readiness for implementation is also included. ITSRs are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published ITSRs are available on the OST Web site at http://apps.em.doe.gov/OST/itsrall.asp

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SECTION 1
SUMMARY

Technology Summary

The U.S. Department of Energy (DOE) continually seeks effective and safer decontamination technologies for use in decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology sponsors large scale Demonstration and Development Projects (LSDDP's) in which developers and vendors of improved and innovative technologies showcase products that are potentially beneficial to DOE projects and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

Los Alamos National Laboratory (LANL) has developed an electrolytic decontamination system (EDS) that has been used to decontaminate stainless steel gloveboxes on a limited basis. This innovative technology is based on electrolysis, where radioactive contaminants are removed from metal surfaces through electrolytic dissolution in a circulating aqueous electrolyte. Advantages of this technology over typical decontamination methods include very high decontamination effectiveness and, since the electrolyte is reused, there is little or no liquid waste generated.

The purpose of this demonstration was twofold –

a) to determine the effectiveness of the EDS to reduce surface contamination to less than 50,000 dpm/100cm^2 for the numerous gloveboxes in the LANL Decontamination and Volume Reduction System (DVRS) area and
b) to determine if the EDS is an effective technology for decontaminating gloveboxes to low levels for ALARA purposes to allow their operational reuse in the LANL TA-55 area. No specific activity level has been defined as the upper limit for reuse of gloveboxes. Therefore, satisfactory decontamination levels are based on the judgement of the operations manager involved.

As a baseline for the demonstration, a traditional chemical means of decontaminating gloveboxes was used that involved wiping down the glovebox surfaces with rags soaked in a dilute acid solution to dissolve and remove actinides from the surfaces. This method has been used for many years at LANL and other DOE sites to decontaminate gloveboxes.

For the LANL electrolytic decontamination technology to prove effective over the baseline technology, it would be required to: 1) remove more contamination than the baseline, 2) produce less waste, 3) be more cost effective, 4) be easier to implement and finally, 5) be safer to operate than the baseline technology.

Problem

The LANL waste inventory includes approximately 200 "legacy" gloveboxes in temporary storage. These gloveboxes will be processed through the LANL DVRS and separated into Low Level Waste (LLW) and transuranic (TRU) waste components. The LLW fraction will be disposed of at LANL, Technical Area 54, Area G, and the TRU fraction will be packaged and certified for ultimate disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. A majority of the gloveboxes to be processed by the DVRS has been classified as TRU.

It is costly to dispose of items in the TRU category. At LANL, the estimated cost for disposal of TRU waste is $34,440 per cubic meter (m^3). By decontaminating to LLW activity levels (i.e., < 100 nCi/g), which are acceptable for disposal at the LANL LLW disposal site, disposal cost is reduced to $7,200 per m^3, an 80% savings.

In addition to cost savings, LLW categorized gloveboxes have an immediate path forward to disposition – they may be disposed of in approved LLW sites. Alternatively, further decontamination enables the reuse of gloveboxes that are not considered obsolete by design. Thereby, all disposal costs could be avoided as well as the cost of replacement.

Traditionally at LANL, gloveboxes were decontaminated by repeatedly scrubbing contaminated surfaces, using nitric acid and polypropylene rags. This method is inefficient, as several iterations are needed to adequately decontaminate the glovebox surfaces. Most significantly, a large volume of contaminated rags is generated with each glovebox decontamination. These rags must be disposed of as TRU waste.

How It Works

The LANL EDS replaces older, less efficient, glovebox decontamination methods with a closed-loop cleaning system. A uniform electrolyte etch is achieved at low voltages and currents in combination with controlled solution chemistry to rapidly strip a few microns from the metal surface, resulting in the removal of surface contamination. The electrolyte solution is monitored and automatically adjusted to keep the pH at a high level promoting the formation of metal hydroxides, which precipitate out of solution. Solution recycle is accomplished by utilizing ultrafiltration with in-line separation of these hydroxides that include the radiological components. This recycle and filtration technique minimizes aqueous process waste and results in minimal solid/radioactive wastes trapped in the disposable filter cartridges. This process has been shown to reduce plutonium and americium contamination by more than 6 orders of magnitude in other applications, permitting the gloveboxes to be disposed of as LLW or reused on location.

Figure 1 - LANL Electrolytic Decontamination System

Demonstration Summary

In this demonstration, the innovative and baseline technologies were used to decontaminate a highly contaminated glovebox in the TA-55 area at LANL. The overall goal was to decontaminate the glovebox for reuse. An additional intermediate goal was to decontaminate the glovebox to LLW activity, less than 50,000 dpm/100cm^2 for gloveboxes.

The innovative technology was the LANL EDS and the baseline technology was wiping down the contaminated surfaces with a dilute nitric acid solution. The purpose of the demonstration was to compare the decontamination efficiencies and the implementation costs for each technology. The LSDDP team recorded operations time from start to finish, total work hours, and expenditures for materials during all phases of the demonstration.

Results

The LANL Electrolytic Decontamination System was successfully demonstrated at the Los Alamos National Laboratory with the following key results:

- Since the actinides were recovered and reprocessed, no liquid waste was generated.
- Contamination levels were reduced to below 50,000 dpm/100 cm^2 (<100 nCi/g) after two passes with the LANL Electrolytic Decontamination System. After two applications using the nitric acid wipe down process, the majority of the glovebox was still above this contamination level.
- After the second application of the EDS, the contamination levels in the glovebox were reduced to levels suitable for reuse. It appears that decontamination levels scale with application time, such that very high decontamination rates can be achieved with prolonged application.
- The LANL Electrolytic Decontamination System resulted in superior Decontamination Factors (DF) than the baseline technology, but at a higher cost. While the cost may be prohibitive for simple decontamination of gloveboxes targeted for disposal, it could be a very effective technology for reuse of gloveboxes.

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All published Innovative Technology Summary Reports are available on the Office of Science and Technology (OST) Web site at http://apps.em.doe.gov/OST/itsrall.asp. The Technology Management System (TMS), available at http://tms.em.doe.gov.ost, provides information about OST programs, technologies, and problems. The OST reference number for the electrolytic decontamination technology demonstration is #3235.

The Los Alamos LSDDP website address is: http://www-emtd.lanl.gov/LSDDP/DDtech.html.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition/Technology Definition

Innovative Technology

Electrolytic decontamination, which is similar to the commercial process of electropolishing, works by applying low direct current (DC) voltage through an electrolyte solution to electrochemically dissolve the uppermost contaminated surface of the glovebox. The system is essentially an electrolytic cell where the glovebox surface is connected to the negative lead of a DC power supply (making it anodic), and a movable fixture to the positive lead making it cathodic. The electrolyte solution, consisting of water and sodium nitrate, flows between the fixture and the contaminated surface. A uniform electrolyte etch is achieved at low voltages and currents (on the order of 3 to 10 volts DC and 40 mA/cm^2) in combination with controlled solution chemistry to rapidly strip the few microns from a metal surface, resulting in the removal of surface contamination.

The process flow diagram for the system is shown in Figure 2. Each unit consists of a detachable hand fixture, a small (approximately 4L) solution reservoir, a centrifugal pump, an ultrafiltration module, a vacuum pump, a pH controller with associated electrode, pH control pump with tank, a stand, and all associated plumbing. A separate, hand held spray bottle (not shown) is used for misting the cleaned glovebox surfaces. All equipment, except for the DC power supply and pH controller is located inside the glovebox while decontaminating.

The moveable hand fixture consists of a plastic body encompassing a stainless steel cathode screen with a protruding electrical connection, inlet and outlet solution ports, and a silicon rubber gasket to seal the fixture to the glovebox surface. LANL has designed rectangular, circular and trianglular fixture heads to decontaminate various surface geometries including rounded corners. The decontamination fixture heads adhere to the surface of the glovebox by the vacuum created by a vacuum pump.

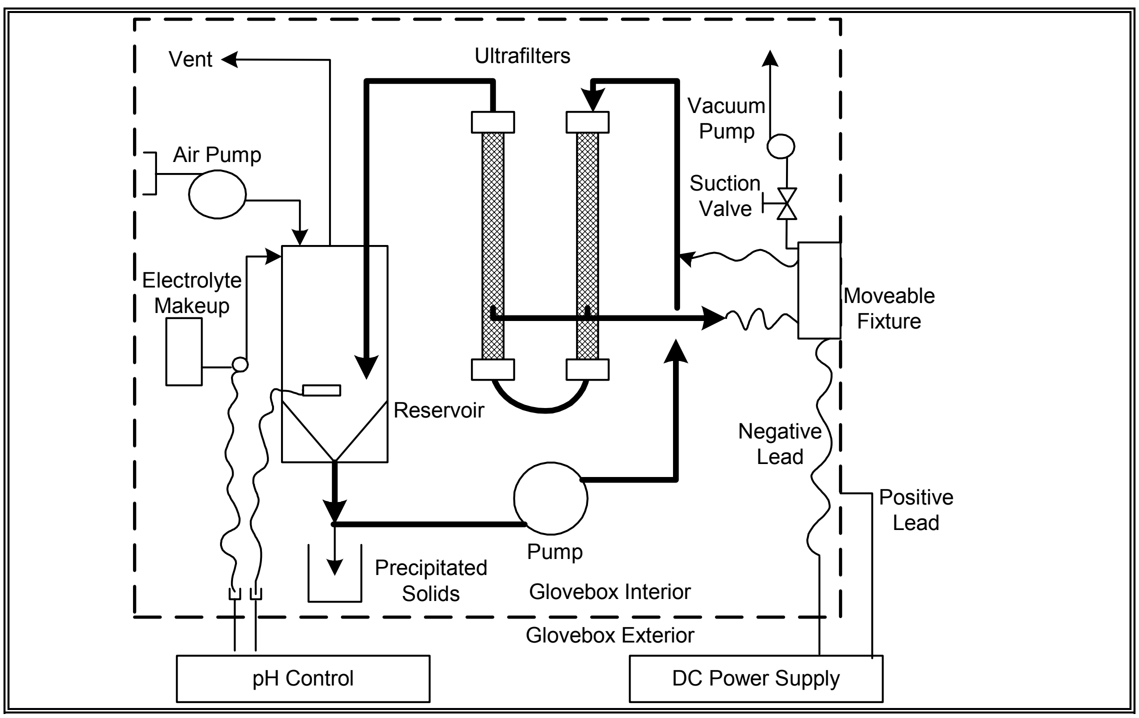

Figure 2 - LANL Electrolytic Decontamination System Flow Diagram

The fixture remains in each location for approximately 30 to 60 seconds. A handheld alpha scintillation probe is used to directly survey the surfaces being decontaminated to quantify the degree of contamination after each movement of the fixture. Initial glovebox contamination levels will generally be >1,000,000 dpm/100cm^2 which is beyond the operating range of the detector. After decontamination of only one minute, surface contamination values are generally found to be in the low thousands to hundreds of dpm/100 cm^2.

In the decontamination process, hydrogen and oxygen are generated through the reduction and oxidation of water respectively. The quantities of these gases generated are small and, for operating gloveboxes, deemed inconsequential for standard airflow conditions provided the hydrogen is dissipated into the bulk volume of the glovebox. For a safety precaution, a small air pump blows a small volume of gas into the reservoir headspace to dilute the evolving gas.

Because both iron and nickel are insoluble in alkaline solutions they precipitate as hydroxides under these conditions. The sodium nitrate electrolyte is maintained at a high pH (10-12) by the pH adjustment equipment through the continuous addition of sodium hydroxide. The precipitated solids are removed from the electrolyte by gravity settling in the reservoir and within the ultrafilters. This separated sludge, when dry, reverts to a mixture of oxides that is amenable to cementation. By adding sodium hydroxide and removing solids, the electrolyte solution may be reused for many gloveboxes, minimizing aqueous process waste. At LANL, one electrolyte volume (approximately 4L) has been reused for many gloveboxes.

Differential pressure gauges are installed on the ultrafilters to indicate filter status. Experience at LANL indicates that these filters should be replaced with new filters after every four gloveboxes.

Baseline Technology

The baseline technology for this demonstration consists of wiping down the glovebox surfaces with a dilute nitric solution. This method has been shown to dissolve the contamination layer covering the base metal, and eventually a part of the base metal. The rags used to apply this technology are most often polypropylene rags. In most cases, the technology can be applied as many times as needed to achieve the desired levels of contamination.

One disadvantage of this technology is that many rags are used resulting in a large volume of secondary waste. Another disadvantage is that excess toxic reagents become hazardous waste.

System Operation

Innovative Technology

The LANL electrolytic decontamination system components may be loaded into the glovebox line through a trolley system, or loaded directly into the glovebox to be decontaminated. The system can be easily assembled and disassembled, the components introduced separately, then assembled within the glovebox. Electrical connections between the system and the glovebox are made through service panels on the glovebox walls or if service panels are unavailable, penetrations into the glovebox can be made. If the system is to be used to decontaminate interconnected gloveboxes, the unit can be stationed in one glovebox and the hose connections to the fixture and electrical connections can be routed to the glovebox being decontaminated.

There are no special wipe-downs or other preparation required before using the system. It is prudent to sweep the floor of the glovebox prior to decontamination to reduce the burden on the system chemistry and to avoid introducing material into the system that may potentially foul quick connects (there is a pre-filter in the loop to avoid fouling of the ultrafilter modules). Also, oils and greases will poison the electrolyte so they must be manually removed from any glovebox before the system can be used.

Decontamination begins by manually placing the fixture head onto the contaminated surface. The fixture head is immediately drawn by vacuum against the surface while the space between the fixture and glovebox quickly fills with solution. The fixture is left in one location for a period of time. The nominal exposure time is on the order of one minute for a 100 cm^2 surface area and is dependent on the level of contamination, the roughness of the surface, the nature of the contamination, and the operating current density.

Following decontamination of a specific area, the fixture's vacuum seal is broken. The fixture, now freed from the surface can be moved to an adjacent location. As the fixture is removed, some solution is spilled to the glovebox floor in this operation, but is readily vacuumed up for return to the reservoir by the fixture. For this reason, the ceiling is typically decontaminated first, followed by the walls and ending with the floor. It is important to note that solution spillage does not contribute to the spread of contamination through the glovebox. The solution fed to the fixture head is free of precipitate and therefore very little, if any, contamination is spread.

The glovebox surfaces are rinsed with a mist of water from the spray bottle after decontamination in order to remove any salt residue. This rinsing process serves two functions. First, it rinses any salts down to the glovebox floor where they may be collected with the fixture head for recycle within the electrolyte. Secondly, it replenishes water lost through evaporation. On average, for a single decontamination unit in operation, only two to three liters of water are lost per day through electrolysis and evaporation.

The sediment collected in the reservoir can be drained from the reservoir and collected in a bottle. The solids and solution are left in the bottle as long as needed for the sediment to gravity separate. The solution at the top of the bottle is poured back into the reservoir.

Baseline Technology

The baseline technology is applied by vigorously wiping down the glovebox surfaces with plastic rags wetted with 0.5M nitric acid solution. It is important to use many rags to prevent contaminants from spreading to previously decontaminated areas. When complete, the rags are placed in a bag and removed from the glovebox.

SECTION 3
PERFORMANCE

Demonstration Plan

Demonstration Site Description

A picture showing the inner surfaces of the glovebox used for this demonstration is shown in Figure 3. The areas of the inner surfaces of the glovebox may be seen in Table 1. This glovebox is 316 stainless steel and has leaded glass windows. The front of the glovebox includes six 15cm (6") gloveports, three viewing windows, and three smaller windows that are located between the gloveports. Equipment is introduced into the glovebox through a 36cm (14") opening on the left side. A dropbox connects to the left side that is connected to a trolley system that allows materials to be introduced into the glovebox line, and moved between gloveboxes in the facility. The glovebox environment is argon. Power (110V AC) for components is available on a service panel located on the right wall within the glovebox. Wiring from the pH probe and DC power supply, outside the glovebox, is fed into the glovebox through penetrations on a service panel located on the right ceiling of the glovebox.

For the demonstration, the LANL Electrolytic Decontamination technology was applied, in accordance with Reference 1, to the left side of the glovebox, while the baseline technology was applied to the right. Prior to starting the demonstration, the entire glovebox was surveyed at various locations on the inner surfaces for loose contamination (smears) and roughly surveyed for direct contamination (alpha probe) to establish an initial contamination level.

Figure 3 – Glovebox left and right internal surfaces (Note: shelves on back wall were removed for the demonstration)

Glovebox Surface	Left Side $m^2(ft^2)$	Right Side $m^2(ft^2)$
Floor	1.10 (11.7)	1.10 (11.7)
Front	0.97 (10.4)	0.97 (10.4)
Back Wall	1.30 (14.0)	1.30 (14.0)
Ceiling	1.01 (10.9)	0.87 (9.4)
Side Wall	0.87 (9.4)	0.87 (9.4)
TOTAL $m^2(ft^2)$	**5.24 (56.4)**	**5.10 (54.9)**

Table 1 – Demonstration Glovebox Surface Areas

Baseline Technology

A technician prepared 1L of 0.5M nitric acid solution and introduced the solution and polypropylene rags into the glovebox line. All surfaces on half of the glovebox were wiped down and then surveyed for remaining direct activity. This process was repeated twice so that three data points could be collected. After the work was finished, the rags were put into a bag, and the bottle containing the dilute acid solution was moved to an adjacent glovebox and bagged out as liquid waste. For the demonstration, the data collected consists of work hours to mobilize, apply, and demobilize the technology. Also recorded were the volume of acid solution used and the volume of rags necessary to complete this phase of the demonstration.

Innovative Technology

The LANL Electrolytic Decontamination System was introduced into the glovebox in nine pieces using the trolley system. Connections to the power supply, pH controller, and alpha probe were made through the service panel located on the ceiling of the glovebox. Once the system was assembled, a cursory run was performed on the floor of the glovebox, which entailed cleaning the glovebox floor using the rectangular fixture and a contact time of 30 to 45 seconds. Subsequently, all glovebox surfaces were decontaminated using appropriate fixtures at a rate that allowed contact times of approximately 60 to 90 seconds. The operating current and voltage were maintained at 10 amps and 10 volts DC (for the maximum decontamination effect) respectively during the entire process. After all surfaces had been decontaminated, each was misted with rinse water. For the demonstration, the data consists of work hours to mobilize, apply and demobilize the technology. Also recorded was the volume of solution used to complete this phase of the demonstration.

Demonstration Objectives

The principal goal of the demonstration was to establish electrolytic decontamination performance and cost data and to compare this data to the baseline technology. This determination would be based on the innovative technology's ability to achieve the following objectives:

- Remove contamination from metal surfaces to LLW activity levels
- Reduce the generation of waste relative to the baseline technology
- Reduce technology application time
- Reduce mobilization/demobilization time
- Reduced personnel requirements
- Reduce material costs

Results

- **Remove contamination from metal surfaces**

The demonstrations of the baseline technology and the LANL EDS were carried out in October and November 2001 at the Los Alamos National Laboratory's TA-55. Before starting the demonstration, surveys on both sides of the glovebox were performed. After each technology was applied, a second survey was performed on each surface. The survey results are summarized in Table 2.

The initial goal of the demonstrations for both technologies was to reduce the glovebox surface contamination levels to 50,000dpm/100cm^2 (or less), from the initial levels indicated in Table 2. An additional goal was to determine if the LANL EDS is an effective technology for decontaminating gloveboxes to a level low enough to allow their operational reuse in the TA-55 area. It was determined that the EDS could decontaminate the glovebox surfaces to the LLW target in two passes. An alpha probe was utilized in conjunction with the EDS fixture head to verify that each treated area was decontaminated below 50,000 dpm/100cm^2 after the second pass.

The results of this application are reported in Table 2. From this data, it can be seen that the innovative EDS technology is more effective for decontaminating to low levels.

Table 2 – Initial and final surface activity

Glovebox Surface	Initial Survey	First Application		Second Application		
	Kdpm/100 cm^2	Kdpm/ 100 cm^2	DF *	Kdpm/100 cm^2	Incremental DF	Total DF
Baseline Technology - LLW Objective						
Back Wall	1,429	429	3.3	57	7.5	25.0
Right Wall	714	286	2.5	143	2.0	5.0
Ceiling	286	186	1.5	29	6.4	10.0
Front Wall	1,429	215	6.7	57	3.8	25.0
Floor	>2857	1,786	1.5	1000	1.8	2.9
Average			**3.1**		**4.3**	**13.6**
Innovative Technology - LLW objective						
Back Wall	>2857	<143	$\geq$20	14	10.0	200.0
Left Wall	1,714	<143	$\geq$12	11	13.0	150.0
Ceiling	286	<143	$\geq$10	9	15.0	33.3
Front Wall	714	<143	$\geq$12.3	1	143.0	500.0
Floor	>2857	<143	$\geq$20	11	10.0	200.0
Average			**$\geq$15**		**38.2**	**176.7**

* Decontamination Factor (DF) is calculated by dividing the initial count by the final count.

- **Reduce the generation of waste relative to the baseline technology**

  The LANL Electrolytic Decontamination System produced waste sediment that was drained from the reservoir. Over the course of the demonstration, a total of 140 grams of solids were collected containing approximately 5 grams of Pu-239. These solids were dried within the glovebox, and were processed elsewhere in the facility. No other waste was produced during the demonstration. However, since the EDS cannot be utilized to decontaminate the non-conductive leaded glass windows, these areas must be decontaminated with the baseline (wipe down) technology. It is estimated that approximately 0.68 M^2 (7.3 ft^2) of the glovebox has leaded glass windows. Based on the results of the baseline demonstration, wipe down of the windows would result in a total of approximately 0.015 cubic meters (4 gallons) of waste rags.

  The baseline technology produced 0.18 cubic meter (6.36 cubic feet) of contaminated polypropylene rags (solid waste) as a result of wiping down the one half of the glovebox surfaces twice. To account for the wiping the entire glovebox, this quantity must be doubled to 0.36 cubic meter. Even after the second wiping every surface of the glovebox, except the ceiling, was still above the target level of 50,000 dpm/100cm^2. For the baseline to reach this target level of decontamination, most of the glovebox surfaces would need to be wiped at one or two more times and the floor would need to be wiped at least three more times. To account for this additional effort, it is assumed that the entire glovebox would need to be wiped the equivalent of three more times. This effort would result in the generation of additional waste rags estimated at 0.5 cubic meter (17.7 cubic feet).

- **Reduce Technology application time and reduce mobilization/demobilization time**

  The time to apply each technology during the mobilization, application and demobilization phases may be seen in Tables 3 and 4.

LANL Electrolytic Decon Sys Demonstration Summary Data				
Innovative Technology				
Mobilization				
Activity		**Hours**		
Survey 1/2 glovebox		0.50		
Set up equipment in hot area		4.75		
Load equipment into glovebox		1.00		
Survey 2nd 1/2 of GB		0.50		
Prepare glovebox wiring		3.50		
Prepared 2L of electrolyte		1.00		
Move electrolyte into room		1.00		
Load electrolyte into glovebox		1.00		
Check system for leaks		2.17		
Prepare wiring inside glovebox		0.87		
Connected wiring outside glovebox		1.67		
Complete assembly of unit inside GB		0.50		
SUBTOTAL		**18.46**		
Monitoring, Sampling & Testing - 2 passes on 1/2 of GB = time req'd for whole GB				
Activity	**1st pass**	**Tot Hours**	**2nd pass**	**Tot Hours**
Decon floor	12.33	24.66	12.33	24.66
Decon corners	2.50	5.00	2.50	5.00
Decon ceiling	2.50	5.00	2.50	5.00
Decon back wall	3.33	6.67	3.33	6.67
Decon left wall	3.16	6.32	3.16	6.32
Decon front wall	1.50	3.00	1.50	3.00
Survey deconned areas	0.83	1.66	0.83	1.66
SUBTOTAL		**52.31**		**52.31**
TOTAL				**104.61**
Demobilization				
Activity		**Hours**		
Disassemble system		1.50		
Drain Precipitate		0.33		
Remove System		0.50		
Bag waste		0.25		
SUBTOTAL		**2.58**		

Table 3 – Electrolytic Decontamination System Demonstration Activities

LANL Baseline Demonstration Summary Data	1/2 GB	Whole GB	4 Passes
Mobilization			
Activity	**Hours**	**Hours**	**Tot Hours**
Survey 1/2 glovebox	0.50	1.00	4.00
Prepare Nitric Acid Solution	0.50	1.00	4.00
Move Nitric Acid Solution into room	0.58	1.16	4.64
Load Nitric Acid Solution into glovebox	1.88	3.76	15.04
SUBTOTAL			**27.68**
Monitoring, Sampling & Testing			
Activity	**Hours**	**Hours**	**Hours**
Wipe down 1/2 of glovebox with HNO_3	0.50	1.00	4.00
Perform 2nd survey	0.33	0.66	2.64
2nd Wipe down	1.17	2.34	9.36
Perform 3rd survey	0.17	0.34	1.36
SUBTOTAL			**17.36**
Demobilization			
Activity	**Hours**	**Hours**	**Hours**
Bag waste rags as TRU waste	0.50	1.00	4.00
Remove rags from glovebox	0.25	0.50	2.00
SUBTOTAL			**6.00**
TOTAL			**51.04**

Table 4 – Baseline Demonstration Activities

As can be seen from the data, the time required for two applications of the innovative technology is considerably higher than four applications of the baseline technology. Mobilization and demobilization requirements are also significantly higher.

- **Reduce personnel requirements**

While the innovative technology requires more time for application, the personnel requirements are similar for both technologies. This is primarily dictated by site specific safety requirements.

- **Reduce material Costs**

The cost of the LANL Electrolytic Decontamination System was approximately $5,200. This cost was amortized over ten glovebox treatments except for the ultrafilters which were amortized over four gloveboxes, based on prior LANL operational experience. Included in this total are the cost of the electrolyte, the costs to fabricate the plastic parts such as the reservoir, hand fixture(s), and the costs to pre-assemble and pre-test the system. Additional estimated costs for acid solution and polypropylene rags needed for decontamination of the windows were added to the cost estimate.

The cost of nitric acid solution used for the baseline demonstration was approximately $100 per gallon. In the demonstration, approximately 1 L of solution was used for the demonstration for ½ of the glovebox, which equates to 8 L for the entire glovebox. The cost of polypropylene rags for 80 bags of rags was approximately $160. It is apparent that material costs for the baseline technology are significantly lower than those for the EDS. The total material cost for each glovebox is approximately $360.

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Technology Applicability

The electrolytic decontamination technology is not limited to use at Los Alamos, but is applicable for use throughout the DOE nuclear complex - where hundreds of gloveboxes are currently located at 6 different facilities. The technology can also be utilized internationally in nuclear facilities and in medical technology production facilities to clean gloveboxes, reduce hazardous waste streams, protect workers from hazardous exposure, and to realize cost savings. Additionally, the technology has the potential to be applied to other contaminated plutonium processing materials including hand tools, machinery, piping, and metal components, thus extending the useful life of these products. Earlier prototypes of EDS's successfully decontaminated these items at other facilities.

Competing Technologies

Two electrochemical technologies have been identified that can be compared to the LANL Electrolytic Decontamination Technology. These are the VNIPIET electrochemical decontamination system and an electrochemical decontamination system developed by ADA Technologies.

The VNIPIET Electrochemical Decontamination System
The system consists of a detachable hand fixture that is manipulated by workers to scrub contaminated surfaces, a process controller that controls the applied current and voltage between the glovebox and hand fixture, and an electrolyte supply tank and pump that provides electrolyte flow through the hand fixture at a specified flow rate. Many different electrolytes have been used within the system for decontamination purposes.

The system is operated by connecting the contaminated metal, in this case a glovebox, to the one terminal of the alternating current power supply within the process controller while the hand fixture is connected to the second terminal. When a current is applied between the glovebox and hand fixture (while electrolyte flows through the hand fixture) the uppermost surface of the glovebox is dissolved into the electrolyte. As the surface layers of the glovebox are dissolved, the contaminants within those layers are freed from the surface, resulting in a decontaminated surface. The electrolyte solution containing the removed contaminants is collected in a reservoir located on the floor of the glovebox. See Reference 2 for additional information.

The ADA Electrodecontamination System
ADA's Electrodecontamination System (Reference 3) is a self-contained unit approximately the same size as a small vehicle battery charger. In this technology, electrolyte gel is pumped from a small reservoir to a hand-held scrubbing fixture that is fitted with a disposable, non-conductive and highly porous abrasive pad. When the pad, full of a gel electrolyte, is brought into contact with a conductive contaminated surface, electrical current passes from the surface, through the electrolyte, then into a protected terminal within a reservoir located in scrubbing fixture. A removable electrolyte film is left behind encapsulating the contaminants. The system has yet to be demonstrated on a plutonium contaminated glovebox, so there can be no direct comparison with this system to the LANL Electrolytic Decontamination System. Despite the lack of sufficient decontamination effectiveness data, this system could offer the following benefits over the LANL Electrochemical Decontamination Technology:

- Gel remains in place on walls and ceilings without running or spreading contamination
- The system is much smaller, and all system components may be placed with a glovebox
- No hazardous offgases are generated during its use.
- No liquids are used.
- Waste includes only contaminated electrolyte strip

One disadvantage of this system could be that the protective coating may need to be removed (manually) if reuse of the glovebox is intended.

Patents/Commercialization/Sponsor

The LANL Electrolytic Decontamination Technology was developed and patented by the Los Alamos Laboratory. Information regarding the design and components will be provided free of charge to interested parties within the DOE complex. LANL can also fabricate a unit, deliver and train personnel to use the technology. Interested parties should contact Doug Wedman (see “Contacts” list, page 7) directly.

SECTION 5
COST

Methodology

The objective of the cost analysis is to provide interested parties with a cost estimate for implementation of the electrolytic decontamination technology on a production scale at a DOE site. This cost estimate considers the costs associated with both technologies on a per glovebox basis. In both technologies two workers are present. A Radiation Control Technician (RCT) is needed to introduce materials into the glovebox lines. For this cost estimate it is assumed that the site will purchase the equipment necessary to construct a LANL electrolytic decontamination system.

The baseline and electrolytic technologies were demonstrated at LANL under controlled conditions (i.e., an in-place glovebox), which facilitated observation of the work procedures and the typical duration of the procedures. To approach realistic implementation costs, additional assumptions were invoked regarding the cost comparison with the baseline technology. This cost analysis compares both technologies based on a unit processing cost.

Key assumptions for the cost estimate/cost comparison are listed below. Other assumptions and details about the cost analysis are presented in Appendix C.

- For the demonstration, each technology was used to decontaminate one half of the glovebox. As shown in Table 1, the left half of the glovebox, which was decontaminated by the electrolytic technology, has an area of 5.24 m^2 (56.4 ft^2). The right half of the glovebox has an area of 5.10 m^2 (54.0 ft^2) and was decontaminated with the baseline technology. To arrive at an implementation cost per glovebox, the time and material costs required to apply each technology were normalized to a unit square meter and extended to a total glovebox inner area of 10.34 m^2 (111.3 ft^2).

- It is assumed that a work team consists of two workers, and one RCT present during surveys, and introduction of equipment into the glovebox line.

- It is assumed that the electrolytic decontamination has been tested and is functional, therefore, there will be no downtime due to equipment malfunctions and testing.

- A DOE site, such as LANL, will purchase all equipment necessary for each Electrolytic Decontamination System for deployment into a radioactive D&D operation and perform any necessary pretreatment prior to removing a glovebox from service.

- No overhead factors were applied to other direct costs.

- Fully burdened labor rates for LANL personnel were used in the estimate.

- Gloveboxes are assumed to be free of equipment, and no other costs to clean or move equipment out of the glovebox were included.

- The protocol for operating the electrolytic decontamination system was assumed to consist of 1) glovebox modifications, 2) introduction of system components into glovebox line, 3) system component assembly, 4) decontaminating the glovebox internal surfaces, and 5) removal of the system.

- No additional procedural costs were involved.

Cost Analysis

To develop estimates for decontamination of gloveboxes to the LLW target (<50,000 dpm/100 cm^2), a cost per glovebox basis was chosen. With a total surface area of 10.34 square meters (111.3 square feet) for the demonstration glovebox, these costs can then be reported in a normalized (per unit area) fashion. Activities were grouped under higher level work titles per the work breakdown structure shown in Reference 4, Hazardous Toxic, Radioactive Waste Remediation Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (U.S. Army Corps of Engineers, 1996).

Using the demonstration costs as a basis, estimates were developed for mobilization, sampling and testing, demobilization and disposal costs for the innovative technology and the baseline technology (nitric acid wipe down). In the demonstration, one half of the glovebox was decontaminated with the innovative technology, while the other half with the baseline technology.

In developing the cost estimate for the baseline technology, the implementation time was doubled to approximate the cost associated with decontaminating the entire glovebox. The innovative technology reached the LLW target with two applications and could decontaminate the glovebox to operational reuse levels. The baseline technology did not reach the LLW target after two applications and it was estimated that a total of four applications would be required to reach this target.

Based on these implementation times, the total estimated costs to decontaminate an entire glovebox to LLW levels (<50K dpm) were $31,051 for the innovative technology and $29,176 for the baseline technology.

Figure 4 compares the implementation costs for the innovative and baseline technologies to LLW disposal levels. The mobilization cost for the innovative technology is greater than that of the baseline technology because of the cost and preparation time of the equipment. The application time for the innovative technology is higher when applied to one glovebox, although more time will be required for the baseline since additional applications are needed to match the decontamination effectiveness of the innovative technology. The demobilization cost for the innovative technology is greater than that of the baseline, since the equipment must be electrically disconnected from the glovebox passthroughs and bagged out. Waste disposal cost for the baseline technology is considerably higher than the innovative technology.

Figure 5 shows the dependency of the glovebox cost on the number of gloveboxes processed for one EDS unit located to service ten gloveboxes. The chart assumes that one unit will be used to decontaminate a line of gloveboxes, where the unit remains in one glovebox and the hose and electrical connections are routed from the glovebox passthroughs to the adjacent gloveboxes. For example, if four gloveboxes are to be decontaminated using one unit, there would be the cost of one mobilization, four applications and one demobilization. For the baseline technology, the cost of processing multiple gloveboxes is simply the total cost of mobilization, application, and demobilization times the number of gloveboxes. From Figure 5, the cost of using EDS and the baseline technologies are equivalent after approximately 1.4 gloveboxes have been processed. After that, the cost difference for the baseline technology diverges rapidly.

Cost Conclusions

The cost estimates provide reasonable costs for implementation of the LANL Electrolytic Decontamination System (innovative technology) and the wipe down (baseline) technology at a DOE site. From the cost estimate section of this report, the costs for each technology to decontaminate the glovebox to less than 50,000 dpm/100cm^2 are:

EDS	$3,003 per square meter	=	$279 per square foot
Wipe down	$2,822 per square meter	=	$262 per square foot

Therefore, the cost of the innovative technology is approximately 6% higher than the cost of the baseline technology but the innovative technology provides better Decontamination Factors. Gloveboxes with greater or lesser surface area will have similar mobilization and demobilization costs although the application time and waste generation volumes will increase or decrease accordingly.

The EDS may be more cost effective if larger areas are to be decontaminated with one mobilization. For example, if multiple gloveboxes are arranged such that the EDS can be introduced into the first glovebox and moved into successive gloveboxes without demobilization, the EDS technology becomes even more cost effective.

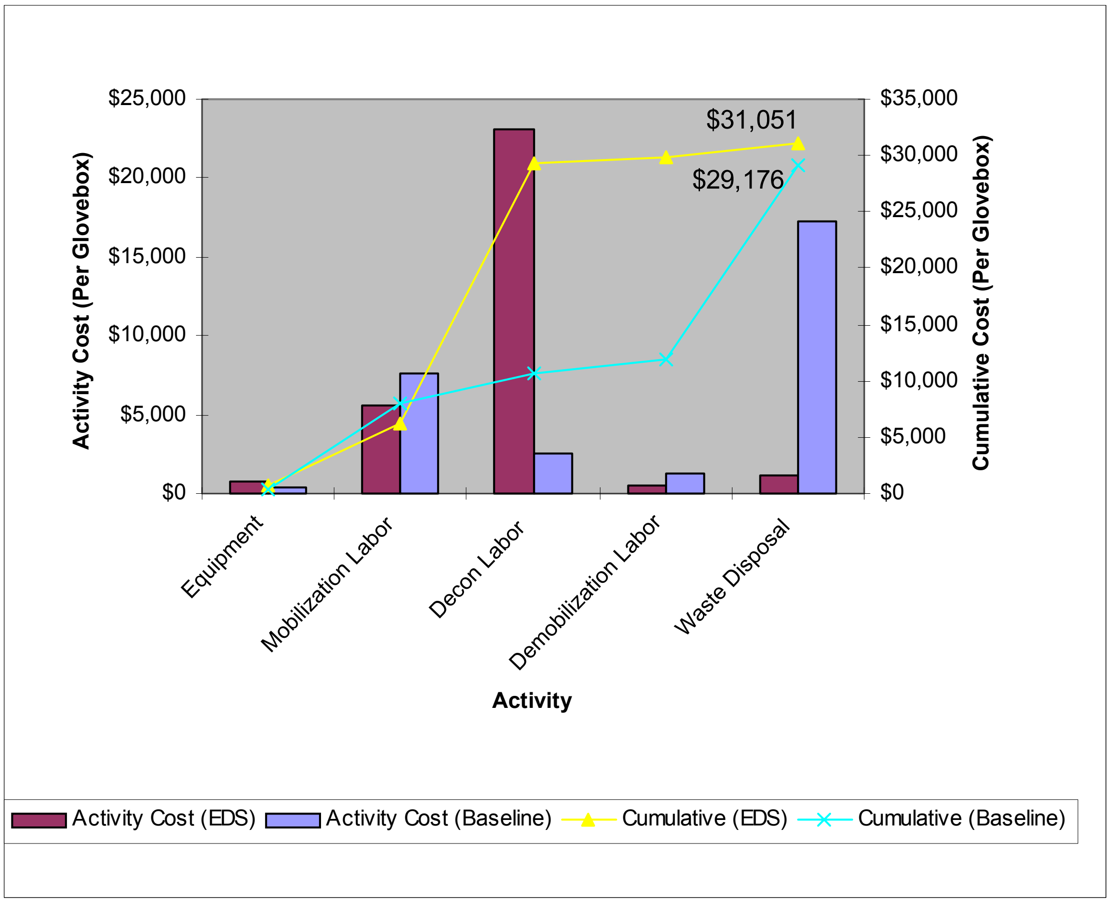

Figure 4 – Glovebox Costs for LANL Electrolytic Decontamination System vs. Baseline

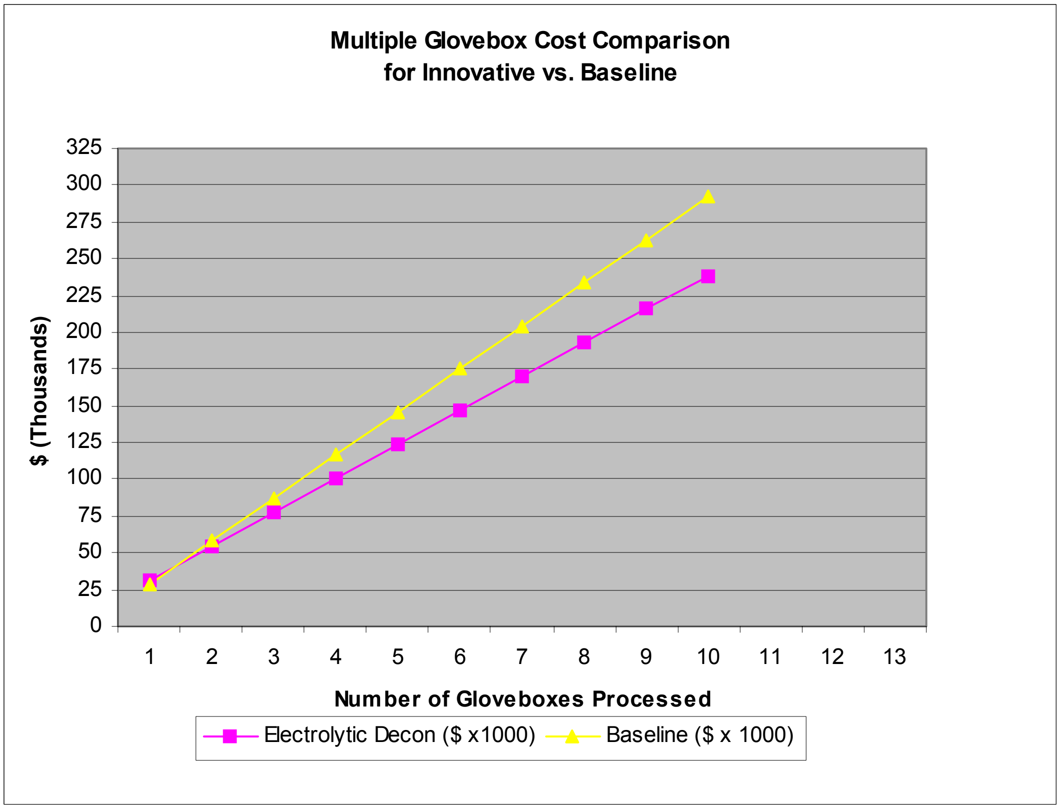

Figure 5 – Multiple Glovebox Cost Comparison for EDS vs. Baseline Technologies

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

Regulations for using the LANL Electrolytic Decontamination are dependent upon each Site's accepted waste regulations.

Safety, Risks, Benefits, and Community Reaction

Worker Safety

Operators of the LANL Electrolytic Decontamination System must be trained in the proper procedures for glovebox work.

In accordance with ALARA principles, workers should minimize potential exposure to radioactive and hazardous materials by proper planning to minimize time spent in work areas, maximize distance between them and hazardous substances, and utilize radiological shielding where applicable.

Community Safety

Community safety is not adversely affected by operation of the LANL Electrolytic Decontamination System. The system will not significantly increase the background radiation in an area. Transportation of the unit poses no risk to the public.

Environmental Impact

There is no negative impact and a potential positive impact to use of the LANL Electrolytic Decontamination System since it has the capability to dramatically reduce contamination levels within gloveboxes before disposal.

Socioeconomic Impacts and Community Reaction

There are no socio-economic impacts associated with the LANL Electrolytic Decontamination System. Community reaction is likely to be positive since less actinide waste will be disposed.

SECTION 7
LESSONS LEARNED

Implementation Considerations

The LANL Electrolytic Decontamination System fabrication drawings, parts lists, training and operating support are available to other DOE sites. The following should be considered when selecting the LANL EDS as a decontamination technology.

- It is recommend that LANL personnel demonstrate proper use of the system before using.
- The site using the LANL Electrolytic Decontamination System must have TRU waste disposal capabilities for sludge and spent ultra-filters.
- Ultra-filters must be kept moist when the system is not in use.
- The system requires a minimum glovebox opening of 14 inches to introduce equipment.
- Materials such as oil, grease, oxides (rust) and paint or other coatings should be removed before decontamination since these substances will damage the electrolyte.
- The pH probes must be calibrated daily, and must be stored in buffer solutions when not in use.
- Decontaminated surfaces must be sprayed down with water to remove salts.
- Typically ultra-filters are replaced once for every four gloveboxes decontaminated.
- There is no need to wipe down surfaces before applying electrolyte as solutions will be collected by the system and recovered with blow down.
- Gloveboxes must have adequate ventilation to dilute hydrogen.

Technology Limitations and Needs for Future Development

The LANL Electrolytic Decontamination System demonstration conclusively proved that it will accomplish the task for which it was designed. It provides DOE a simple means of reducing contamination levels within gloveboxes that will be reused or disposed. It is limited to the following:

- Electrochemical processes may only be applied for removing radionuclide contamination from conducting surfaces, such as iron-based alloys (including stainless steel), copper, aluminum, lead and molybdenum.
- Because the system works only on surfaces suitable for the currently designed fixtures, it can not be used to decontaminate objects within the glovebox with complex geometry. Therefore, these items must be decontaminated using another means such as nitric acid wipe down.
- The electrolyte tends to heat up after a few hours of operation, producing steam that condenses on the glovebox windows and prevents observation.
- The technology can not be used on insulating surfaces such as glass or rubber. Another means of decontamination must be used for these surfaces.

Technology Selection Considerations

- Adequate area for the positioning of the system within gloveboxes.
- 110V power must be available for system electrical components.
- To be used in a D&D environment, the site must have the capability to dispose of the solids that are drained from the reservoir. It is expected that these solids can be dried within the glovebox that has been decontaminated, and bagged from the glovebox as TRU waste.

APPENDIX A
REFERENCES

1. IT Corporation, 2001, Test Plan for LANL electrolytic decontamination technology demonstration.

2. Final Report for the project ”Detailed Analysis of Applicability of Electrochemical and Foam Decontamination Techniques for the needs of Los Alamos National Laboratory”, Alexander Pavlov, VNIPEIT. (Report available through DDFA).

3. ADA Technology, “Electrodecontamination Becomes Practical”. (Available from ADA)

4. U.S. Army Corps of Engineers (USACE). 1996. Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure, Prepared for the U.S. Department of Energy, draft January.

APPENDIX B
ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
DC	Direct Current
DOE	U.S. Department of Energy
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
dpm	disintegrations per minute
DVRS	Decontamination and Volume Reduction System
EDS	Electrolytic Decontamination System
HTRW RA WBS	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure
ITSR	Innovative Technology Summary Report
LANL	Los Alamos National Laboratory
LLW	Low Level Waste
LSDDP	Large-scale Demonstration and Deployment Project
NCi/g	nanocuries per gram
OST	Office of Science and Technology
RCT	Radiation control technician
TA	Technical Area
TMS	Technology Management System
TRU	Transuranic
WBS	Work Breakdown Structure

APPENDIX C
TECHNOLOGY COST COMPARISON

Basis of Estimated Cost

The activity titles shown in this cost analysis for implementation were derived from observation of the work performed and from a reasonable estimate of the level of effort required for implementation at other DOE sites. In the estimate the activities are grouped under higher level work titles according to the work breakdown structure shown in the Reference 4; Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS). The HTRW RA WBS was developed by an interagency group, and is used in this analysis to provide consistency with the established national standards.

The goal of the decontamination efforts for each technology was to reduce residual fixed contamination to a level which would result in a specific activity level below 50,000 dpm/cm^2, i.e. within the Low Level Waste category. A secondary goal was to determine what lower activity limits were achievable within a reasonable time. This effort was aimed at the potential to prepare the glovebox for reuse for other operations. Additional assumptions are delineated in Section 5 of the main document.

The costs shown in this analysis are computed from observed duration and hourly rates for the crew, supplies, and equipment.

The costs for each of the technologies were based on two separate efforts to decontaminate each half of an operational glovebox, complete with exhaust ventilation and power pass throughs, at LANL. The overall surface area treated inside the glovebox was 10.34m^2 (111.3 ft^2). The time intervals for the various tasks performed for the baseline technology were recorded and then doubled to reflect the estimated cost for a whole glovebox. The initial EDS application involved semi-real time monitoring with an alpha probe after each fixture movement to ensure that the surfaces were decontaminated to below the LLW target. The second EDS application was performed on one half of the glovebox to determine to what level it could be decontaminated within a reasonable timeframe. The total time for both of these applications was used to reflect the equivalent time to decontaminate the whole glovebox.

Activity Descriptions

Mobilization and Preparatory Work (WBS 33.1.01)

Mobilization of Equipment – Mobilization of equipment includes purchasing one LANL electrolytic decontamination system, and chemicals. The electrolytic decontamination system, including all system components, has been quoted by LANL personnel to be approximately $5,200. This cost was adjusted by a factor of 0.10 (0.25 for the ultrafilters) to effectively amortize it over the decontamination of ten similar gloveboxes.

Mobilization of Personnel – For this cost estimate, it was assumed that mobilization begins at the glovebox entry point where the innovative technology system has been disassembled and bagged ready to enter the glovebox line. Per LANL procedures (two-man rule), two technicians and one RCT are required to introduce the equipment into the glovebox line via the trolley system. It is assumed that a site implementing these technologies will have similar requirements. Once the equipment has been received into the glovebox, two technicians assembled the system, connect electrical equipment to glovebox service panels, and then add 4L of electrolyte to the system.

Submittals/Implementation Plans – Plans and permits were assumed to be complete prior to the start of work and will not be considered in this cost estimate.

Monitoring, Sampling & Testing (WBS 33.1.02)

Two technicians are present to apply both the baseline and innovative technologies. Therefore, two technicians are required to operate one unit. An RCT is present to conduct surveys.

The results presented in Table 2, show that the baseline technology did not reduce contamination levels on all surfaces below the target 50,000 dpm/100 cm^2 after two passes on the walls and ceilings. It was assumed in this cost estimate that the equivalent of three more additional passes, for the whole glovebox, could achieve the decontamination goal of 50,000 dpm/100 cm^2.

The application times for the baseline technology were approximately 1/2 hour for the initial pass followed by 20 minutes (0.33 hour) to survey the surfaces. The second pass took 1.17 hours and 0.17 hours to survey. To adjust these times to the entire surface area, the times were doubled resulting in 1 hour to decontaminate the glovebox surfaces for the first pass and 2.34 hours for subsequent passes. Adjusting the survey times for a whole glovebox results in 0.67 hour for the first survey and 0.33 hour for subsequent surveys. Since three additional passes are required the total times were estimated as shown in Table 4.

The target decontamination level of 50,000 dpm/100 cm^2 was achieved in two applications with the innovative technology. The secondary goal was also achieved after two applications. The total time required to complete the two passes on one half of the glovebox using the innovative technology was approximately 26.15 hours. This time is equivalent to applying the innovative technology to the entire glovebox. Additional time and material costs, for wiping down the windows with nitric acid, were included in the estimate (prorated from the baseline technology costs)

Demobilization (WBS 33.1.21)

Equipment Decontamination and Release – For this estimate, it is assumed that equipment inside the glovebox will ultimately be packaged for disposal as waste instead of being decontaminated. A prorated cost ($350/ea. for ten gloveboxes) for disposal of the EDS unit as LLW was included in the estimate.

Waste Generation (WBS 33.1.18)

Approximately 141 grams (5 ounces) of solid fines were collected during the innovative technology demonstration resulting from draining the solids from the reservoir. These fines are estimated to have a dry volume of approximately 42 milliliters, which translates into a near negligible cost ($1.43) associated with disposing of this waste. Also, the cost for waste rag disposal, that would result from window wipe down, was also included ($552.80).

The baseline technology produced approximately 0.18 cubic meter (6.4 cubic foot) of waste during the demonstration for one half of the glovebox. For this cost estimate, the waste volume was estimated at approximately 0.50 cubic meters of TRU waste during decontaminating of the entire glovebox. The cost of disposing TRU waste is approximately $34,550 per cubic meter ($966 per cubic foot)**.** For a glovebox with a surface area of 10.34 square meters (111.3 square feet), the cost to dispose of this waste would be $17,275 per glovebox.

Cost Estimate Summary

The cost analysis details are summarized in Tables C-1 and C-2. The tables break out each member of the crew, each labor rate, and each piece of equipment use.

TABLE C-1 Baseline Estimated Implementation Cost

TITLE	LABOR	MATERIALS	LABOR QUANTITY	UNIT OF MEASURE	UNIT COST	QUANTITY	SUBTOTAL
Mobilization and Preparatory Work (WBS 33.1.01)							**$8,031.20**
Materials							**$360.00**
Wipe Down Equipment							***$360.00***
		Nitric Acid		Lump	$200.00	1.00	$200.00
		Rags		Bag	$2.00	80.00	$160.00
Labor							**$7,671.20**
Technicians							***$5,091.20***
	Assist with survey		1	Hour	$107.50	4.00	$430.00
	Prepare decon solution		1	Hour	$107.50	4.00	$430.00
	Move acid solution into room		2	Hour	$107.50	4.64	$997.60
	Load materials into glovebox		2	Hour	$107.50	15.04	$3,233.60
Radiological Control Technician (RCT)							***$2,580.00***
	Load materials into glovebox		1	Hour	$107.50	16.00	$1,720.00
	Perform survey		1	Hour	$107.50	8.00	$860.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$2,580.00**
Labor							**$2,580.00**
Technicians							***$1,720.00***
	Wipe down glovebox with HNO_3 solution		2	Hour	$107.50	4.00	$860.00
	Assist with survey		2	Hour	$107.50	2.64	$567.60
	Assist with survey		2	Hour	$107.50	1.36	$292.40
Radiological Control Technician (RCT)							***$860.00***
	Perform survey		1	Hour	$107.50	8.00	$860.00
Demobilization (WBS 33.1.21)							**$1,290.00**
Labor							***$1,290.00***
Technicians							$1,290.00
	Bag waste rags as TRU waste		2	Hour	$107.50	4.00	$860.00
	Remove rags from glovebox		2	Hour	$107.50	2.00	$430.00
Waste Generation (WBS 33.1.18)							**$17,275.00**
	Dispose waste rags as TRU waste			cubic meter	$34,550.00	0.50	17,275.00
TOTAL							**$29,176.20**

TABLE C-2 LANL Electrochemical Decontamination Estimated Implementation Cost

TITLE	LABOR	MATERIALS	LABOR QUANTITY	UNIT OF MEASURE	UNIT COST	QUANTITY	SUBTOTAL
Mobilization and Preparatory Work (WBS 33.1.01)							**$6,290.68**
Materials							**$710.00**
Electrochemical Decontamination Equipment - amortized over 10 gloveboxes							***$710.00***
		Centrifugal Pump/Motor		Lump	$600.00	0.10	$60.00
		UltraFilters		Lump	$1,000.00	0.25	$250.00
		pH Adjustment Equip		Lump	$1,000.00	0.10	$100.00
		Power Supply		Lump	$500.00	0.10	$50.00
		Pipe/Tubing/Fittings		Lump	$500.00	0.10	$50.00
		Reservoir		Lump	$400.00	0.10	$40.00
		Fixture		Lump	$500.00	0.10	$50.00
		Stand		Lump	$200.00	0.10	$20.00
		Vacuum Pump		Lump	$500.00	0.10	$50.00
		Nitric Acid		Lump	$20.00	1.00	$20.00
		Rags		Bag	$2.00	10.00	$20.00
Labor							**$5,580.68**
Technicians							***$5,473.18***
	Training site personnel		2	Hour	$107.50	8.00	$1,720.00
	Assist with survey		1	Hour	$107.50	0.50	$53.75
	Set up equipment in hot area		2	Hour	$107.50	4.75	$1,021.25
	Load equipment into glovebox		2	Hour	$107.50	1.00	$215.00
	Prepare glovebox wiring		2	Hour	$107.50	3.50	$752.50
	Prepared 2L of electrolyte		1	Hour	$107.50	1.00	$107.50
	Prepare 1/2 L of nitric acid solution		1	Hour	$107.50	0.50	$53.75
	Move electrolyte and nitric acid into room		2	Hour	$107.50	1.00	$215.00
	Load electrolyte and nitric acid into glovebox		2	Hour	$107.50	1.00	$215.00
	Check system for leaks		2	Hour	$107.50	2.17	$466.55
	Prepare wiring inside glovebox		2	Hour	$107.50	0.87	$187.05
	Connected wiring outside glovebox		2	Hour	$107.50	1.67	$358.33
	Complete assembly of decon unit inside GB		2	Hour	$107.50	0.50	$107.50
Radiological Control Technician (RCT)							***$107.50***
	Perform survey		1	Hour	$107.50	1.00	$107.50
Monitoring, Sampling & Testing (WBS 33.1.02)							**$23,063.48**
Labor							**$23,063.48**
Technicians							***$22,706.58***
	Decon floor		2	Hour	$107.50	49.32	$10,603.80
	Decon corners		2	Hour	$107.50	10.00	$2,150.00
	Decon ceiling		2	Hour	$107.50	10.00	$2,150.00
	Decon back wall		2	Hour	$107.50	13.33	$2,866.38
	Deconleft wall		2	Hour	$107.50	12.64	$2,717.60
	Decon front wall		2	Hour	$107.50	6.00	$1,290.00
	Wipe down windows with nitric acid		2	Hour	$107.50	1.00	$215.00
	Assist with survey		2	Hour	$107.50	3.32	$713.80
Radiological Control Technician (RCT)							***$356.90***
	Perform survey		1	Hour	$107.50	3.32	$356.90
Demobilization (WBS 33.1.21)							**$555.41**
Labor							***$555.41***
Technicians							$555.41
	Disassemble system		2	Hour	$107.50	1.50	$322.50
	Drain Precip		2	Hour	$107.50	0.33	$71.66
	Mop up		2	Hour	$107.50	0.50	$107.50
	Bag waste		2	Hour	$107.50	0.25	$53.75
	Remove wastes		2	Hour	$107.50	0.50	$107.50
Waste Generation (WBS 33.1.18)							**$1,141.32**
	Waste rags as TRU waste			cubic meter	$34,550.00	0.032	$1,105.60
	Cemented waste			liter	$7.20	0.100	$0.72
	Decon unit disposal (LLW-amortized over 10 GB)			Lump	$350.00	0.100	$35.00
TOTAL							**$31,050.89**